REMARKS

New Claims 13 through 24 have been added and are currently pending in the present application. Original claims 1 through 12 have been cancelled. In view of the above amendment, applicant believes the pending application is in condition for allowance.

Thus, prompt and favorable consideration of this amendment is respectfully requested. If the Examiner believes that personal communication will expedite prosecution of this application, the Examiner is invited to telephone the undersigned at (248) 641-1600.

Applicant believes no fee is due with this response. However, if a fee is due, please charge our Deposit Account No. 08-0750, under Order No. 6340-000075/NP from which the undersigned is authorized to draw.

Dated: May 31, 2006

Respectfully submitted,

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A BEARING APPARATUS FOR A WHEEL OF VEHICLE

CROSS-REFERENCE TO RELATED APPLICATIONS

[0001] This application is a National Stage of International Application No. PCT/JP2004/015144, filed October 14, 2004, which claims priority to Japanese Patent Application No. 2003-401112, filed December 1, 2003, Japanese Patent Application No. 2004-0079683, filed March 19, 2004 and Japanese Patent Application No. 2004-269093, filed September 16, 2004. The disclosures of the above applications are incorporated herein by reference.

FIELD

~~Field of the Invention~~

[0002] ~~—~~The present disclosure~~invention~~ relates to a vehicle wheel bearing apparatus ~~for a wheel of vehicle for~~to rotatably support~~ing~~ the wheel relative to a suspension apparatus of the vehicle~~,~~ and, more particularly, to a vehicle wheel bearing apparatus ~~for a wheel of vehicle~~ of the semi-floating type where~~in which~~ a driving wheel is supported by a double row rolling bearing.

BACKGROUND

~~Description of Background Art~~

[0003] ~~—~~In a vehicle such as a truck having a body with a ~~of~~ frame structure, an axle structure of a driving wheel of a full-floating type bearing has been widely adopted. In ~~a~~ recent driving wheel supporting structure, a unit structure of a double row rolling bearing ~~there~~ has been widely adopted ~~a unit structure of a double row rolling bearing~~. This unit~~so as to improve~~ improves the readiness of assembly~~,~~

and reduction of weight and size. One example of such a prior art vehicle wheel bearing apparatus ~~for a wheel of vehicle of the prior art~~ is shown in Fig. 9.

[0004] In this vehicle wheel bearing apparatus~~ for a wheel of vehicle~~, a ~~driving~~drive shaft 52, connected to a differential apparatus (not shown), is inserted into an axle housing 51. A~~ and a~~ double row conical roller bearing 53 is mounted on the axle housing 51. A ~~hub~~ wheel hub 54 is rotatably supported by the double row conical roller bearing 53. The wheel hub 54 is connected to a flange 56 via hub bolts 55. A pair of inner ~~ring~~rings 57 is~~are~~ connected to each other by a connecting ring 58. The rings 57 are~~ and~~ fit~~ted~~ onto the end of the axle housing 51 and then securely fastened by a fastening nut 59. ~~On the other hand an~~An outer ring 60 of the double row conical roller bearing is fitted into the ~~hub wheel~~wheel hub 54. The outer ring 60 is~~ and~~ axially secured by~~with its~~ both its ends being sandwiched by the flange 56 of the ~~driving~~drive shaft 52 and a brake rotor 61. ~~A double~~Double row conical rollers 62 are rollably contained by cages 63 between the annular space between the inner and outer rings 57 and 60. Seals~~ and seals~~ 64 are arranged at both ends of the annular space to seal off the inside of the wheel bearing ~~off~~ from the outside.

[0005] The inboard side end of the inner ring 57 is formed with an annular stepped portion 65. The stepped portion 65 receives and mounts ~~on which~~ a seal ring 66~~ is mounted~~. An annular recess 67 is formed on the outer circumferential surfaces of the inner rings 57 at mutually abutted portions of the pair of inner rings 57. An elastic~~ and a~~ seal ring 68 ~~of elastic member~~ is fit~~ted~~ into the recess 67~~therein~~. These seal rings 66 and 68 prevent penetration or ingress of rain water or dusts into the axle housing 51, leakage of differential gear oil to the outside and

ingress of the differential gear oil into the inside of the bearing (see Japanese Laid-open Patent publication No. 99172/2001).

~~Disclosure of the Invention~~
~~Problems to be solved by the Invention~~

[0006] However since the prior art vehicle wheel bearing apparatus ~~for a wheel of vehicle of the prior art~~ has a structure where~~such that~~ the double row of conical roller bearing 53 is arranged between the ~~hub wheel~~wheel hub 54 and the axle housing 51, ~~and that~~ the driving shaft 52 is inserted into the axle housing 51 and ~~then~~ the flange 56 of this ~~driving~~drive shaft 52 is connected to the ~~hub wheel~~wheel hub 54 by the hub bolts 55, a reduction of the weight and size of the bearing apparatus is limited. Also, the ~~as well as~~ assembly of the bearing apparatus is complicated ~~by~~due to the requirement of a large number of structural parts.

SUMMARY OF THE INVENTION

[0007] It is therefore an object of the present disclosure~~invention~~ to provide a vehicle wheel bearing apparatus ~~for a wheel of vehicle~~ which can reduce the weight, size and ~~a~~the number of parts. Also, a bearing apparatus ~~and also~~ can prevent the ingress of rain water or dusts and the leakage of differential gear oil.

[0008] ~~For achieving the object, there is provided, according~~According to the present disclosure, a vehicle wheel ~~invention of claim 1, a~~ bearing apparatus ~~for a wheel of vehicle comprising:~~comprises an axle housing supported under a body of a vehicle. ~~A; a~~ hollow ~~driving~~drive shaft is inserted into the axle housing. ~~A; and a~~ wheel bearing is arranged between the ~~driving~~drive shaft and an opening of the axle housing and is structured as a unit of a ~~hub wheel~~wheel hub and a double row rolling

bearing. The~~;~~ ~~the~~ wheel bearing ~~comprising:~~comprises an inner member which includes~~including~~ a ~~hub wheel~~wheel hub with an integrally formed wheel mounting flange on one end ~~thereof with a wheel mounting flange~~ and ~~having~~ an axially extending cylindrical portion. At least one inner~~; and inner~~ ring~~s~~ is press-~~fitted~~fit onto the cylindrical portion of the ~~hub wheel~~wheel hub. The ~~and formed on which~~ ~~o~~outer circumferential surface of the inner ring is formed with at least one of the inner raceway surfaces. An~~; an~~ outer member is arranged around the inner member. The outer member is ~~and~~ formed with double row outer raceway surfaces on its inner circumferential surface. The outer raceway surfaces are ~~oppositely~~opposite to the inner raceway surfaces. Double~~; double~~ row rolling elements are arranged between the inner and outer raceway surfaces of the inner member and the outer member. A~~;~~ ~~a~~ cage ~~for~~ freely rollably h~~holding~~olds the rolling elements. Seals are provided to ~~;~~ ~~and seals for sealing~~seal an annular space between the inner member and the outer member. A cap, with a ~~; characterized in that a cap having~~ metal core formed from~~of~~ steel, is press-~~fitted~~fit into an end of a central bore of the ~~hub wheel~~wheel hub.

[0009] ~~According to the present invention of claim 1, since~~Since ~~a~~the cap, with the steel ~~having~~ metal core ~~of steel,~~ is press-fit~~ted~~ into an end of the central bore of the ~~hub wheel~~wheel hub forming the wheel bearing apparatus, it is possible to provide a vehicle wheel bearing apparatus ~~for a wheel of vehicle~~ of a semi-floating type which can reduce ~~the~~ weight and size. Also, the bearing apparatus ~~and also~~ can prevent the leakage of differential gear oil to the outside as well as prevent the ingress of rain water or dusts from the outside into the differential gear oil through the ~~driving~~drive shaft.

[0010] ~~According to the present invention of claim 2, since~~Since ~~said~~ at least one of the inner raceway surfaces is formed directly on the outer circumferential surface of the ~~hub wheel~~wheel hub, it is possible to further reduce the bearing weight and size and increase the rigidity of the bearing.

[0011] ~~According to the present invention of claim 3, since~~ Since the end of the~~said~~ cylindrical portion is radially outwardly plastically deformed ~~radially outward~~ to form a caulked portion ~~for~~to ~~preventing~~prevent the inner ring from ~~being slipped~~slipping off ~~from~~ the cylindrical portion of the ~~hub wheel~~wheel hub, it is unnecessary to control the amount of preload of the bearing as in the prior art, by tightly fastening a nut on the inner ring ~~using a nut~~. Thus, the ease ~~easiness~~ of assembly of the bearing apparatus ~~to~~onto a vehicle can be improved. Also, ~~and~~ the predetermined amount of preload can be kept for a long term. In addition, it is possible to substantially reduce the number of parts and to reduce ~~the~~ manufacturing cost, ~~and the~~ weight and size of the bearing due to the improvements in ~~of~~ the ~~easiness~~ease of ~~assemble~~assembly.

[0012] ~~Preferably according to the present invention of claim 4, since~~Since the outer circumferential region of the wheel mounting flange, from its base to the~~of~~ inboard side to the cylindrical portion, is hardened by high frequency induction hardening to have a~~as having the~~ surface hardness of 54~~~~64 HRC, and the caulked portion ~~is remained~~remains unhardened to have a ~~as having the~~ surface hardness of 25 HRC or less after forging, it is possible to improve the durability of the ~~hub wheel~~wheel hub and workability of the caulked portion during its plastic deformation. Thus, ~~and thus the~~ reliability of the quality of the bearing is improved.

[0013] ~~According to the present invention of claim 5,~~ Ssince the~~said~~ cap is press-~~fitted~~fit into the central bore of the wheel hub wheel mounting flange ~~of hub wheel~~, the cap can be positioned at a region with~~having~~ high rigidity of the ~~hub wheel~~wheel hub. Accordingly, the cap is scarcely influenced by elastic deformation of the ~~hub wheel~~wheel hub and thus, it is possible to prevent the generation of a radial gap between the cap and the ~~hub wheel~~wheel hub.

[0014] ~~According to the present invention of claim 6, since~~Since ~~said~~the cap ~~comprises~~includes a metal core made of steel with~~having~~ a ~~cross-section of~~ substantially "C" shaped configuration cross-section and an elastic member is attached to at least part of its fitting portion, the elastic member can intimately contact the fitting surface and thus can securely seal the inside of the ~~hub wheel~~wheel hub.

[0015] ~~According to the present invention of claim 7, since~~Since ~~said~~the cap is press-~~fitted~~fit so that the circumferential edge of its fitting portion is oriented toward the outboard side, the press-fitting operation can be easily carried out. In addition, since the edge side of low rigidity is positioned at the outboard side, the cap does not move toward the outboard side. Thus, ~~and thus~~ slipping off of the cap from the ~~hub wheel~~wheel hub can be prevented even ~~although~~though the metal core is moved axially due to its deformation caused by elastic deformation of the ~~hub wheel~~wheel hub.

[0016] ~~According to the present invention of claim 8, since~~Since the~~said~~ circumferential edge of the fitting portion of the metal core is formed with an~~a bead~~

extending radially outward bead, and an annular groove ~~with~~ which engages the bead ~~engages~~ is formed on the central bore of the ~~hub wheel~~wheel hub, it is possible to securely prevent ~~the~~ axial movement of the cap. This ~~and thus to~~ further ~~improve~~improves the reliability of the cap.

[0017] Since~~According to the present invention of claim 9, since~~ the~~said~~ cap is limited against ~~an~~ axial movement by steps provided at either ~~sides~~ side of the cap, it is possible to securely prevent the cap ~~being~~from ~~slipped~~slipping off from the ~~hub wheel~~wheel hub even though~~although~~ the ~~hub wheel~~wheel hub is elastically deformed by a repeating load applied to it ~~thereto~~ during running of a vehicle.

[0018] ~~According to the present invention of claim 10, since~~Since the~~said~~ cap ~~comprises~~includes a metal core made of steel with~~having~~ a ~~cross-section of~~ substantially "C" shaped configuration cross section, an annular recess is formed on the inner circumferential surface of the ~~hub wheel~~wheel hub, and the fitting portion of the cap is formed with a projection adapted to ~~be~~ engage~~d with~~ the annular recess, it is possible to easily mount the cap on the ~~hub wheel~~wheel hub and to prevent ~~the~~ axial movement of the cap with a simple structure.

[0019] ~~Preferably according to the present invention of claim 11, since~~Since the~~said~~ projection is formed by plastic deformation after the cap has been press-~~fitted~~fit into the bore of the ~~hub wheel~~wheel hub, the cap can be further intimately fitted into the annular groove of the ~~hub wheel~~wheel hub without any rattle. Thus, ~~and thus the~~ axial movement of the cap and also~~therefore~~ ~~the~~ leakage of differential gear oil can be further prevented by the mating of the projection and bore.

[0020] Since~~Preferably according to the present invention of claim 12, since~~ the ~~said~~ cap is press-fit~~ted~~ with ~~a~~an interference of 0.05~~~~~0.3 mm, it is possible to prevent the generation of ~~the~~a radial gap between the cap and the ~~hub wheel~~wheel hub due to errors in configuration of the cap. Thus, this prevents ~~and thus to prevent the~~ leakage of differential gear oil therethrough. In addition, the cap can be easily press-~~fitted~~fit into the ~~hub wheel~~wheel hub and ~~the~~ buckling of the cap, which would be caused by large interference, can also be ~~also~~ prevented.

~~Effect of the Invention~~

[0021] ~~According to the~~The vehicle wheel bearing apparatus ~~for a wheel of vehicle~~ of the present ~~invention~~disclosure, ~~which, since it~~ comprises an axle housing supported under a body of vehicle; a hollow ~~driving~~ drive shaft inserted into the axle housing; ~~and~~ a wheel bearing arranged between the ~~driving~~drive shaft and an opening of the axle housing which is~~and~~ structured as a unit of a ~~hub wheel~~wheel hub and a double row rolling bearing; the wheel bearing ~~comprising:~~comprises an inner member ~~with~~~~including~~ a ~~hub wheel~~wheel hub integrally formed with a wheel mounting flange on one end ~~thereof with a wheel mounting flange~~ and having an axially extending cylindrical portion; at least one ~~and~~ inner ring~~s~~ is press-~~fitted~~fit onto the cylindrical portion of the ~~hub wheel~~wheel hub and is formed on its~~which~~ outer circumferential surface with at least one of the inner raceway surfaces; an outer member is arranged around the inner member and is formed with double row outer raceway surfaces on its inner circumferential surface ~~oppositely~~opposite to the inner raceway surfaces; double row rolling elements are arranged between the inner and outer raceway surfaces of the inner member and the outer member; a cage ~~for~~ freely rollably ~~holding~~holds the rolling elements; and seals ~~for sealing~~seal an annular space

between the inner member and the outer member; ~~and it is characterized in that~~ a cap, with a~~having~~ metal core of steel, is press-~~fitted~~fit into an end of a central bore of the ~~hub wheel~~wheel hub, makes it ~~is~~ possible to provide a vehicle wheel bearing apparatus of ~~for a wheel of vehicle of~~ a semi-floating type which can reduce the weight and size of the bearing apparatus. Also, it ~~and also can prevent~~prevents ~~the~~ leakage of differential gear oil to the outside as well as the ingress of rain water or dusts from the outside into the differential gear oil through the ~~driving~~drive shaft.

~~Best mode for carrying out the Invention~~

[0022] According to the disclosure~~present invention~~, ~~there is provided~~ a vehicle wheel bearing apparatus ~~for a wheel of vehicle comprising~~comprises~~:~~ an axle housing supported under a body of the vehicle. ~~A;~~ ~~a~~ hollow ~~driving~~drive shaft is inserted into the axle housing. ~~A; and a~~ wheel bearing is arranged between the ~~driving~~drive shaft and an opening of the axle housing. The wheel bearing is~~and~~ structured as a unit with~~of~~ a ~~hub wheel~~wheel hub and a double row rolling bearing. The~~; the~~ wheel bearing has~~comprising:~~ an inner member which includes~~including~~ a ~~hub wheel~~wheel hub integrally formed with a wheel mounting flange on one end ~~thereof with a wheel mounting flange~~ and ~~having~~ an axially extending cylindrical portion. At least one inner ring is~~; and inner rings~~ press-~~fitted~~fit onto the cylindrical portion of the ~~hub wheel~~wheel hub. The inner ring ~~and formed on which outer circumferential surface~~outer circumferential surface is formed with at least one ~~of~~ inner raceway surfaces. An~~; an~~ outer member is arranged around the inner member. The outer member is ~~and~~ formed with double row outer raceway surfaces on its inner circumferential surface ~~oppositely~~opposite to the inner raceway surfaces. Double~~;~~ ~~double~~ row rolling elements are arranged between the inner and outer raceway

surfaces of the inner member and the outer member. A~~; a~~ cage ~~for~~ freely rollably ~~holding~~holds the rolling elements. Seals~~; and seals~~ seal ~~for sealing~~ an annular space between the inner member and the outer member. A~~; characterized in that a~~ cap, with a ~~having~~ metal core of steel, is press-fit~~ted~~ into an end of a central bore of the ~~hub wheel~~wheel hub.

BRIEF DESCRIPTION OF THE DRAWINGS

[0023] Additional advantages and features of the present disclosure~~invention~~ will become apparent from the subsequent description and the appended claims, taken in conjunction with the accompanying drawings, wherein:

[0024] Fig. 1 is a longitudinal-section view of a first embodiment of a vehicle wheel bearing apparatus ~~for a wheel of vehicle of the present invention~~;

[0025] Fig. 2 is a partially enlarged longitudinal-section view of Fig. 1 ~~showing a wheel bearing~~;

[0026] Fig. 3 is a longitudinal-section view of a second embodiment of a vehicle wheel bearing apparatus ~~for a wheel of vehicle of the present invention~~;

[0027] Fig. 4 is a partially enlarged longitudinal-section view of Fig. 3;

[0028] Fig. 5 is a longitudinal-section view of a third embodiment of a vehicle bearing apparatus ~~for a wheel of vehicle of the present invention~~;

[0029] Fig. 6 is a longitudinal-section view of a fourth embodiment of a vehicle wheel bearing apparatus ~~for a wheel of vehicle of the present invention~~;

[0030] Fig. 7(a) and 7(b) are a partially enlarged longitudinal-section view of a modification of the fourth embodiment showing, respectively, a condition of a cap before and after caulking ~~thereof~~;

[0031] Fig. 8 is a longitudinal-section view of a fifth embodiment of a vehicle wheel bearing apparatus ~~for a wheel of vehicle of the present invention~~; and

[0032] Fig. 9 is a longitudinal-section view of a prior art vehicle wheel bearing apparatus ~~for a wheel of vehicle of the prior art~~.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[0033] Preferred embodiments of the present disclosure~~invention~~ will be described with reference to the ~~accompanied~~accompanying drawings.

~~First embodiment~~

[0034] Fig. 1 is a longitudinal-section view of a first embodiment of a vehicle wheel bearing apparatus~~, for a wheel of the present invention, and~~ Fig. 2 is a partially enlarged longitudinal-section view of Fig. 1. In the present description ~~of the present invention~~, a side of ~~a~~the bearing positioned outward of a vehicle, when it is mounted on ~~a~~the vehicle, is referred to as the "outboard" side (the left side in a drawing). ~~A, and a~~ side inward of the~~a~~ vehicle is referred to as the "inboard" side (the right side in a drawing).

[0035] In ~~a~~the vehicle wheel bearing apparatus ~~for a wheel of vehicle of the present invention~~, a ~~hub wheel~~wheel hub 1 and a double row rolling bearing 2 are formed as a unit and are connected to a ~~driving~~drive shaft "D/S". The double row rolling bearing 2 includes~~comprises~~ an inner member 3, an outer member 4, and ~~a~~ double row rolling elements (tapered rollers) 5 freely rollably contained between the inner and outer members 3 and 4. The inner member 3 includes the ~~hub wheel~~wheel hub 1 and a pair of inner rings 10 press-~~fitted~~fit onto the ~~hub wheel~~wheel hub 1. The

~~hub wheel~~wheel hub 1 is integrally formed, at its outboard side, with a wheel mounting flange 6 on which, a wheel "W" and a brake rotor "B" are mounted. An ~~and from which an~~ axially extending cylindrical portion 7 extends from the flange 6. An inner circumferential surface (bore) of the ~~hub wheel~~wheel hub 1 is formed with a serration (or spline) 8 to receive~~into which~~ a serrated portion of the ~~driving~~drive shaft "D/S" to transmit~~is inserted so that a~~ torque between the two ~~can be transmitted therebetween~~.

[0036] As shown in Fig. 2, the double row rolling bearing 2 includes~~comprises~~ an outer member 4 formed with double row outer raceway surfaces 4a on its inner circumferential surface. A ~~and with a~~ body mounting flange 4b is formed on the outer member 4. The flange 4b is to be ~~to be~~ secured on an axle housing "H" on its outer circumferential surface. A, ~~a~~ pair of inner rings 10 are inserted into the outer member 4. The inner rings 10 are ~~and~~ formed with double row tapered inner raceway surfaces 10a, 10a on ~~its~~their outer circumferential surface oppositeoppositely to the outer raceway surfaces 4a. Double, ~~double~~ row rolling elements 5 are arranged between the inner and outer raceway surfaces 10a, 4a. A, ~~and a~~ cage 11 ~~for~~ freely rollably ~~holding~~holds the rolling elements 5. Each of the inner rings 10 is formed with, at its larger diameter end, a large flange 10b to guide~~for guiding~~ the rolling elements 5. The pair of inner rings 10 ~~are~~is arranged so that their inner ends ~~are~~ abut~~ted~~ each other. Thus, they ~~and thus~~ form a ~~so~~so-called ~~a~~ back-abutted type double row tapered roller bearing. Seals 12 are arranged at both~~either~~ ends of the outer member 4 to seal an annular space between the outer member 4 and the inner rings 10. ~~These~~ The seals 12 prevent both penetration of

rain water or dusts from ~~the~~ external circumstances and leakage of lubricating grease sealed within the bearing. The inboard side seal 12 further prevents penetration or ingress of differential gear oil into the inside of the bearing.

[0037] The pair of inner rings 10 are press-~~fitted~~fit onto the cylindrical portion 7 of the ~~hub wheel~~wheel hub 1. The inner rings 10 ~~and~~ are prevented from ~~being~~ axially ~~slipped~~slipping off of ~~from~~ the cylindrical portion 7 by a caulked portion 13. The caulked portion is formed by plastically deforming the end of the cylindrical portion 7 radially outward. Since this embodiment adopts the self-retaining structure of the second generation, it is not required to control an amount of preload as in a conventional manner by tightly fastening a nut against the inner ring. Accordingly, it is possible to substantially reduce the number of parts and thus to improve the readiness of assembly as well as to reduce its manufacturing cost, size and weight ~~and size~~.

[0038] The ~~hub wheel~~wheel hub 1 is made of medium carbon steel such as S53C which ~~including~~includes carbon of 0.40~~~~0.80% by weight. The wheel hub 1 is ~~and~~ hardened by high frequency induction quenching so that the base of the wheel mounting flange 6, at its inboard side, and the cylindrical portion 7 of the ~~hub wheel~~wheel hub 1 have a~~the~~ surface hardness of 54~~~~64 HRC (the hardened portion is shown in drawings by cross-hatched lines). The caulked portion 13 ~~is remained~~ remains as a~~an~~ unhardened portion and has ~~having~~ its surface hardness of 25 HRC or less. This improves the durability and workability of the caulked portion 13 and also prevents the generation of cracks ~~therein~~.

[0039] The outer member 4 is also made of medium carbon steel such as S53C which includes~~including~~ carbon of 0.40~~~~0.80% by weight. The~~ and the~~ double row outer raceway surfaces 4a and inner circumferential surface of the outer member 4, on which the seal 12 is mounted, are hardened by high frequency induction quenching so that their surface hardness is within 54~~~~64 HRC. ~~On the other hand, the~~The inner rings 10 are~~is~~ made of high carbon chrome bearing steel such as SUJ2. The inner rings 10 are ~~and~~ hardened to the~~its~~ core by ~~dipping~~dip quenching to have ~~the~~a surface hardness of HRC 54~~~~64. Even ~~Although~~though the~~it is herein illustrated a~~ double row tapered roller bearing is illustrated using ~~using~~ tapered roller as the rolling elements 5, ~~the~~a double row angular ball bearing using balls may ~~be~~ also be used.

[0040] In this embodiment, a cap 9 is press-fit~~ted~~ into an opening of the ~~hub wheel~~wheel hub 1 at its outboard side. This cap 9 is made of austenitic-stainless steel sheet (JIS SUS 304 etc.) or preserved cold rolled steel sheet (JIS SPCC etc.) and is formed as an annular shape by press working. The cap 9 ~~comprises~~includes a metal core 9a formed from ~~of~~ steel. The cap 9 has ~~formed as having~~ a substantially "C"-shaped cross-section. An~~, and an~~ elastic member 9b, of rubber, is bonded, via vulcanization, to at least the fitting portion of the metal core 9a. The elastic member 9b is elastically deformed during the press fitting of the cap 9 ~~is press-fitted~~ into the opening of the ~~hub wheel~~wheel hub 1 to seal the opening. The seal ~~for~~ surely ~~preventing~~prevents ingress of rain water or dusts from the ambient circumstances into the ~~driving~~drive shaft "D/S" and thus into the differential gear oil.

[0041] It is preferable that the cap 9 is press-fittedfit into the hub wheelwheel hub 1 with a interference of 0.05~~-~~0.3 mm. This is because theat differential gear oil could leak through a small radial gap which would be caused in the fitting portion between the hub wheelwheel hub 1 and the cap 9 due to dimensional errors of the cap itself when the interference is less than 0.05 mm. On~~,~~ on the other hand, the press-fitting operation of the cap 9 would becomebecomes difficult and buckling of the metal core may occur itself would be caused when the interference is larger than 0.3 mm. In addition, it is preferable that the cap 9 is press-fittedfit into the hub wheelwheel hub 1 at a high rigid bore portion. That is, thereof, that is a bore portion of the hub wheelwheel hub 1 at or near the wheel mounting flange 6. Accordingly, the cap 9 is scarcely influenced by elastic deformation of the hub wheelwheel hub 1 althougheven though the hub wheelwheel hub 1 would be deformed by applying repeatingrepeated moment loads applied thereto.

Second embodiment

[0042] Fig. 3 is a longitudinal-section view of a second embodiment of the vehicle wheela bearing apparatus for a wheel of vehicle of the present invention. Since the difference between of this embodiment andfrom the first embodiment only resides in the structure of the hub wheelwheel hub, the same numerals are used as those used in the first embodiment for designatingto designate the same structural elements.

[0043] ThisThe vehicle wheel bearing apparatus for a wheel of vehicle is structured as a unit with the of the hub wheelwheel hub 14 and a double row rolling bearing 15. The double row rolling bearing 15 comprisesincludes an inner member

16, an outer member 4, and a double row rolling elements 5 and 5 freely rollably contained between the inner and outer members 16 and 4. The inner member 16 includes the ~~hub wheel~~wheel hub 14 and the inner ring 10 press-~~fitted~~fit onto the ~~hub wheel~~wheel hub 14. The ~~hub wheel~~wheel hub 14 is integrally formed, at its outboard side, with a wheel mounting flange 6 on which, a wheel (not shown in Fig. 3) is mounted. An ~~and with an~~ inner raceway surface 14a is formed on the wheel hub 14 on ~~of~~ the outboard side of the bearing 15. Also, the wheel hub 14 ~~and~~ has the cylindrical portion 7 axially extending from the inner raceway surface 14a. The ~~hub wheel~~wheel hub 14 is formed with a serration (or spline) 8 on its inner circumferential surface (bore) to receive~~with a serration (or spline) 8 into which~~ a serrated portion of the ~~driving~~drive shaft (not shown in Fig. 3) ~~is inserted so that a~~to ~~-~~transmit torque between the two~~can be transmitted therebetween~~.

[0044] The outer circumferential surface of the ~~hub wheel~~wheel hub 14 is formed with a flange portion 14b, corresponding to the large flange 10b of the inner ring 10, and a stepped portion 14c, ~~to~~ which abuts an inner end face (smaller end face)~~abuts~~. Thus, the so-called back-abutted type double row tapered roller bearing is formed~~structured~~. In addition, the ~~The~~ inner ring 10 is press-~~fitted~~fit onto the cylindrical portion 7 of the ~~hub wheel~~wheel hub 14. The inner ring 10 ~~and~~ is prevented from ~~being~~ axially ~~slipped~~slipping off off~~from~~ the cylindrical portion 7 by a caulked portion 13. The caulked portion 13 is formed by plastically deforming the end of the cylindrical portion 7 radially outward. Since this embodiment adopts a~~the~~ self-retaining structure of such a third generation, it is not required to control an amount of preload in~~as~~ a manner similar to the first embodiment by tightly fastening

a nut against the inner ring. Accordingly, it is possible to improve the readiness of assembly as well as to maintain the amount of preload for a long term.

[0045] Since the inner raceway surface 14a is directly formed on the outer circumferential surface of the ~~hub wheel~~wheel hub 14, the rigidity of the ~~hub wheel~~wheel hub 14 is increased. Accordingly, it is possible to reduce the size and weight ~~and size~~ of the bearing apparatus and to improve its even ~~though although~~ the ~~hub wheel~~wheel hub 14 would be deformed by an ~~a~~ moment load applied ~~applied thereto~~ during running of the vehicle.

[0046] ~~In this embodiment a~~ A cap 17 is press-fitted into an opening of the ~~hub wheel~~wheel hub 14 at its outboard side. ~~This~~The cap 17 is made of austenitic-stainless steel sheet (JIS SUS 304 etc.) or preserved cold rolled steel sheet (JIS SPCC etc.) and includes~~comprises~~ a metal core 18. The cap 17 is formed ~~as having~~to have a substantially "C"-shaped cross-section. An~~, and an~~ elastic member 19, of rubber, is bonded via vulcanization, to the outer surface of the metal core 18. The metal core 18 is press-~~fitted~~fit into the ~~hub wheel~~wheel hub 14 so that the circumferential edge of the cylindrical fitting portion 18a is oriented toward the outboard side. This makes the press-fitting operation of the cap 17 easy. In addition, since the edge portion of the cap 17, having low rigidity, is positioned at the outboard side, the cap 17 does not move toward the outboard side. Thus, ~~and thus~~ it is possible to prevent the cap 17 from~~being slipped~~ slipping off ~~from~~ the ~~hub wheel~~wheel hub 14 even though~~although~~ the metal core 18 is deformed due to the elastic deformation of the ~~hub wheel~~wheel hub 14.

[0047] As clearly shown in Fig. 4, a bead 18b~~there~~ is formed at the circumferential edge. ~~The a~~ bead 18b ~~extending~~extends radially outward. It is possible to securely prevent axial movement of the cap 17 by engaging the bead 18b with an annular groove 20 formed on the inner circumferential surface (bore) of the ~~hub wheel~~wheel hub 14.

~~Third embodiment~~

[0048] Fig. 5 is an enlarged partial view of a third embodiment of a vehicle wheel bearing apparatus ~~for a wheel of vehicle of the present invention~~. The~~Same~~ same numerals are used ~~herein~~ as those ~~used~~ in the previous embodiments ~~for~~to designate ~~designating~~ the same structural elements.

[0049] In this embodiment, a cap 21 is press-~~fitted~~fit into an opening of the ~~hub wheel~~wheel hub 1 at its outboard side. ~~This~~ The cap 21 is made of austenitic-stainless steel sheet (JIS SUS 304 etc.) or preserved cold rolled steel sheet (JIS SPCC etc.) and includes~~comprises~~ a metal core 21a formed from ~~of~~ steel. The cap 21 has ~~formed as having~~ a substantially "C"-shaped cross-section. An, ~~and an~~ elastic member 21b extended from the inner circumferential surface to the cylindrical fitting portion of the metal core 21b. The elastic member 21b is formed from ~~comprises~~ a material such as rubber bonded, via vulcanization, to the surface of the metal core 21a. The elastic member 21b ~~and has~~ functions ~~of preventing~~to prevent the generation of rust on the metal core 21a and ~~sealing~~seals the inside of the ~~hub wheel~~wheel hub 1 from the outside with intimate contact of the elastic member 21b to the inner circumferential surface (bore) of the ~~hub wheel~~wheel hub 1. Accordingly, it is possible to prevent ingress of rain water or dusts from ~~the~~ ambient

circumstances into the ~~driving~~drive shaft and thus into the differential gear oil. Also, it is possible to prevent ~~and~~ leakage of the differential gear oil to the outside.

[0050] The axial movement of the cap 21 is limited by a stop ring 22 secured on the inner circumferential surface of the ~~hub wheel~~wheel hub 1, and a stepped portion 23. Thus, it is possible to prevent the cap 21 from slipping~~being slipped~~ off ~~from~~ the ~~hub wheel~~wheel hub 1 even though~~although~~ the ~~hub wheel~~wheel hub 1 is deformed by the repeated~~repeating~~ moment load applied ~~applied thereto~~ during running of the vehicle. Projections 24, co-axially formed on the metal core 21a, increase the rigidity of the metal core 21a and improve the buckling resistance.

~~Fourth embodiment~~

[0051] Fig. 6 is an enlarged partial view of a fourth embodiment of the vehicle wheel~~a~~ bearing apparatus ~~for a wheel of vehicle of the present invention~~. The same~~Same~~ numerals are used ~~herein~~ as those used in the previous embodiments ~~for designating~~to designate the same structural elements.

[0052] In this embodiment, an annular recess 25, having a circular arc cross section, is formed on the inner circumferential surface (bore) of the ~~hub wheel~~wheel hub 1. ~~A and a~~ cap 26 is formed with a projection 26a having a cross section corresponding to the annular recess 25. The cap 26 is snapped ~~therein~~into the recess 25. This makes the mounting of the cap 26 easy and also~~enables to prevent~~ prevents ~~the~~ axial movement of the cap 26 with a simple structure. In this case, it is unnecessary to form the projection 26a on the whole circumference of the cap 26. Thus, ~~and~~ three or more projections will sufficiently perform this function.

[0053] Fig. 7 is a partially enlarged longitudinal-section view of a modification of the fourth embodiment. ~~Same~~ The same numerals are used ~~herein~~ as those used in the previous embodiment (Fig. 6) ~~for designating~~to designate the same structural elements.

[0054] A cap 27' has a ~~cross section of~~ substantially "C"-shaped configuration cross section and is press-~~fitted~~fit into the inner circumferential surface (bore) of the ~~hub wheel~~wheel hub 1 with a predetermined interference. ~~Then the~~The cap 27' is plastically deformed by a rolling tool and fitted into the annular recess 25. The formed projection 26a ~~thus formed~~ can further intimately contact the annular recess 25 of the ~~hub wheel~~wheel hub 1 without rattle. Accordingly, it is possible to further effectively prevent ~~the~~ axial movement of the cap 27' and to securely prevent ~~the~~ leakage of the differential gear oil by this projection 26a in cooperation with the fitting portion 26b.

~~Fifth embodiment~~

[0055] Fig. ~~8~~6 is an enlarged partial view of a fifth embodiment of the vehicle wheel~~a~~ bearing apparatus ~~for a wheel of vehicle of the present invention~~. The~~Same~~ same numerals are used ~~herein~~ as those used in the previous embodiments ~~for designating~~to designate the same structural elements.

[0056] In this embodiment, a cap 29 is press-~~fitted~~fit into the ~~hub wheel~~wheel hub 1 over a region of the inner circumferential surface (bore) from its opened end at the outboard side to a pilot portion 28. The cap 29 is made of austenitic-stainless steel sheet (JIS SUS 304 etc.) or preserved cold rolled steel

sheet (JIS SPCC etc.). The cap 29 includes ~~and comprises~~ a metal core 29a press-formed ~~as having~~to have a substantially "hat"-shaped cross-section. An~~, and an~~ elastic member 29b, of rubber, is bonded, via vulcanization, over a region ~~from the outer circumferential surface~~ of the metal core 29a from the outer circumferential surface to the fitting portion and the outboard side end of the ~~hub wheel~~wheel hub 1.

[0057] The elastic member 29b is formed of ~~comprises~~ rubber etc. and is ~~being~~ bonded to the metal core 29a, via ~~e.g.~~ vulcanization, and can ~~perfectly~~ prevent ~~the~~ leakage of differential gear oil and ingress of rain water or dusts into the differential gear oil through the ~~driving~~drive shaft. In addition, since the cap 29 closes the whole ~~the~~ opened portion of the ~~hub wheel~~wheel hub 1and it is press-~~fitted~~fit into the portion of the ~~hub wheel~~wheel hub 1 which is less deformed even~~although~~ though the ~~repeating~~repeated moment load is applied to the ~~hub wheel~~wheel hub 1, it is possible to further prevent the elastic deformation of the cap 29 and its ~~slip~~slipping off from the ~~hub wheel~~wheel hub 1.

~~Applicability in industry~~

[0058] The vehicle wheel bearing apparatus ~~for a wheel of vehicle of the present invention~~ can be applied to ~~a bearing apparatus for a wheel of vehicle of~~ the driving wheel side of the semi-floating type where~~in which~~ a wheel bearing is arranged in opened portions between a ~~driving~~drive shaft and a axle housing.

[0059] The present ~~invention~~disclosure has been described with reference to the preferred embodiment. Obviously, modifications and alternations will occur to those of ordinary skill in the art upon reading and understanding the preceding

detailed description. It is intended that the present disclosure~~invention~~ be construed as including all such alternations and modifications insofar as they come within the scope of the appended claims or ~~the~~their equivalents ~~thereof~~.

WHAT IS CLAIMED IS:

~~—~~1. ~~—~~A vehicle wheel bearing apparatus for a wheel of vehicle comprising:

~~—~~an axle housing ~~"H"~~ supported under a body of a vehicle;

~~—~~a hollow ~~driving~~drive shaft ~~"D/S"~~ inserted into the axle housing ~~"H"~~;

~~and~~

~~—~~a wheel bearing arranged between the ~~driving~~drive shaft ~~"D/S"~~ and an opening of the axle housing ~~"H"~~ and structured as a unit of a ~~hub wheel~~wheel hub ~~(1, 14)~~ and a double row rolling bearing ~~(2, 15)~~;

~~—~~the wheel bearing comprising:

~~—~~an inner member ~~(3, 16)~~ including a ~~hub wheel~~wheel hub ~~(1, 14)~~ integrally formed with a wheel mounting flange on one end ~~thereof with a wheel mounting flange (6)~~ and ~~having~~ an axially extending cylindrical portion ~~(7)~~;

~~—~~~~and~~at least one inner ~~rings~~ring ~~(10)~~ press-~~fitted~~fit onto the cylindrical portion ~~(7)~~ of the ~~hub wheel~~wheel hub ~~(1, 14)~~ and said at least one inner ring with at least one inner raceway surface formed on its~~which~~ outer circumferential surface ~~with at least one of inner raceway surfaces (10a)~~;

~~—~~an outer member ~~(4)~~ arranged around the inner member ~~(3, 16)~~ and formed with double row outer raceway surfaces ~~(4a)~~ on its inner circumferential surface ~~oppositely~~opposite to the inner raceway surfaces ~~(10a)~~;

~~—~~double row rolling elements ~~(5)~~ arranged between the inner and outer raceway surfaces ~~(10a, 4a)~~ of the inner member ~~(3, 16)~~ and the outer member ~~(4)~~;

~~—~~a cage ~~(11)~~ for freely rollably holding the rolling elements ~~(5); and~~

seals (12 and 13) for sealing an annular space between the inner member (3, 16) and the outer member (4); and

characterized in that a cap (9, 17, 21, 26, 27', 29) having a metal core (9a, 18, 21a, 29a) of steel is press-fittedfit into an end of a central bore of the hub wheelwheel hub (1, 14).

2. The vehicle wheelA bearing apparatus for a wheel of vehicle of claim 1 wherein said at least one (14a) of said inner raceway surfaces (10a) is formed directly on the outer circumferential surface of the hub wheelwheel hub (1, 14).

33. The vehicle wheelA bearing apparatus for a wheel of vehicle of claim 1 wherein the end of said cylindrical portion (7) is plastically deformed radially outward to form a caulked portion (13) tofor preventingprevent the inner ring (10) from being slippedslipping off offrom the cylindrical portion (7) of the hub wheelwheel hub (1, 14).

4. AThe vehicle wheel bearing apparatus for a wheel of vehicle of claim 3 wherein the outer circumferential region of the wheel mounting flange (6) from its base of of an inboard side to the cylindrical portion (7) is hardened by high frequency induction hardening to haveas having the a surface hardness of 54~~64 HRC, and the caulked portion (13) is remained remains unhardened to have aas having the surface hardness of 25 HRC or less after forging.

~~_____~~—5. ~~-~~The ~~A~~ vehicle wheel bearing apparatus ~~for a wheel of vehicle~~ of claim 1 wherein said cap ~~(9, 17, 21, 26, 27', 29)~~ is press-~~fitted~~fit into a~~the~~ central bore of the wheel mounting flange ~~(6)~~ of ~~hub wheel~~wheel hub.

~~(1, 14).~~

~~_____~~—6. ~~-~~The vehicle wheel~~A~~ bearing apparatus ~~for a wheel of vehicle~~ of claim 1 wherein said cap ~~(9, 17, 21, 26, 27', 29)~~ comprises a metal core ~~(9a, 18, 21a, 29a)~~ of steel having a ~~cross-section of~~ substantially "C" shaped configuration cross section and an elastic member ~~(9b, 19, 21b, 29b)~~ attached to at least part of its fitting portion.

~~_____~~—7. ~~-A~~The vehicle wheel ~~-~~bearing apparatus ~~for a wheel of vehicle~~ of claim 6 wherein said cap ~~(9, 17, 21, 26, 27', 29)~~ is press-~~fitted~~fit so that the circumferential edge of its fitting portion is oriented toward the outboard side.

~~_____~~—8. ~~-~~The vehicle wheel~~A~~ bearing apparatus ~~for a wheel of vehicle~~ of claim 6 wherein said circumferential edge of the fitting portion of the metal core ~~(9a, 18, 21a, 29a)~~ is formed with a radially outwardly extending bead~~bead (18a) extending radially outward~~, and an annular groove ~~(20) with which the bead (18a) engages~~ is formed on the central bore of the ~~hub wheel~~wheel hub to engage the bead ~~(1, 14)~~.

~~_____~~—9. ~~-~~The vehicle wheel ~~A~~ bearing apparatus ~~for a wheel of vehicle~~ of claim 6 wherein said cap ~~(9, 17, 21, 26, 27', 29)~~ is limited against ~~an~~ axial movement by steps ~~(22, 23)~~ provided at either sides of the cap ~~(9, 17, 21, 26, 27', 29)~~.

~~_____~~—10. ~~-~~The vehicle wheel ~~A bearing~~bearing apparatus ~~for a wheel of vehicle~~ of claim 1 wherein said cap ~~(26)~~ comprises a metal core ~~of steel~~ having a ~~cross-section of~~ substantially "C"~~-~~shaped configuration cross section, an annular recess ~~(25)~~ is formed on the inner circumferential surface of the ~~hub wheel~~wheel hub ~~(1, 14)~~, and the fitting portion of the cap ~~(26)~~ is formed with a projection ~~(26a)~~ adapted to be engaged with the annular recess ~~(25)~~.

~~_____~~—11. ~~-~~The vehicle wheel ~~A~~ bearing apparatus ~~for a wheel of vehicle~~ of claim 10 wherein said projection ~~(26a)~~ is formed by plastic deformation after the cap ~~(27')~~ has been press-~~fitted~~fit into the bore of the ~~hub wheel~~wheel hub ~~(1, 14)~~.

~~_____~~—12. ~~-~~The vehicle wheel~~A~~ bearing apparatus ~~for a wheel of vehicle~~ of claim 1 wherein said cap ~~(9, 17, 21, 26, 27', 29)~~ is press-~~fitted~~fit with ~~a~~an interference of 0.05~~~~~0.3 mm.

ABSTRACT OF DISCLOSURE

~~An object of the present invention is to provide a~~A vehicle wheel bearing apparatus ~~for a wheel of vehicle w~~which ~~can reduce~~reduces the weight, size and ~~a~~ number of parts and also ~~can prevent~~prevents ingress of rain water or dusts and leakage of differential gear oil has~~. According to the present invention there is provided a bearing apparatus for a wheel of vehicle comprising:~~ an axle housing supported under a body of a vehicle. A~~; a~~ hollow ~~driving~~drive shaft is inserted into the axle housing. A~~; and a~~ wheel bearing is arranged between the ~~driving~~drive shaft and an opening of the axle housing and is structured as a unit including~~of~~ a ~~hub wheel~~wheel hub and a double row rolling bearing. The~~; the~~ wheel bearing includes~~comprising:~~ an inner member with~~including~~ a ~~hub wheel~~wheel hub integrally formed with a wheel mounting flange on one end ~~thereof with a wheel mounting flange~~ and ~~having~~ an axially extending cylindrical portion. At least one~~; and inner rings~~ inner ring is press-~~fitted~~fit onto the cylindrical portion of the ~~hub wheel~~wheel hub. The inner ring is ~~and~~ formed with at least one of the inner raceway surfaces on its~~which~~ outer circumferential surface. An ~~with at least one of inner raceway surfaces; an~~ outer member is arranged around the inner member and formed with double row outer raceway surfaces on its inner circumferential surface ~~oppositely~~opposite to the inner raceway surfaces~~;~~. Double ~~double~~ row rolling elements are arranged between the inner and outer raceway surfaces of the inner member and the outer member. A cage~~; a cage~~ ~~for~~ freely rollably ~~holding~~holds the rolling elements. Seals ~~; and seals~~seal ~~for sealing~~ an annular space between the inner member and the outer member. A cap, ~~; characterized in that a cap h~~having a

metal core formed from~~of~~ steel, is press-~~fitted~~ fit into an end of a central bore of the ~~hub wheel~~wheel hub.